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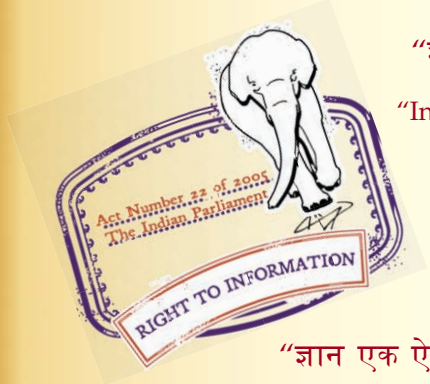
IS 15071 (2002): Chemical Protective Clothing--Specification. ICS 13.340.10



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Indian Standard

CHEMICAL PROTECTIVE CLOTHING — SPECIFICATION

ICS 13.340.10

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Industrial Safety Sectional Committee had been approved by the Chemical Division Council.

Increased use of chemicals, phenomenal growth of process industries, and introduction of more complex and hazardous processes result in enhanced potential of chemical exposure. Engineering measures are the most preferred method to prevent/control exposure to hazardous chemicals. However, many times, as the last line of defence, personal protective equipment are relied upon to control chemical exposure of personnel. Chemical protective clothing is one of the key personal protective equipment for this purpose.

Protective clothing comes in a wide range of types and materials, depending on the hazard to which one is likely to be exposed in the work environment.

The primary function of protective clothing is to prevent, or reduce to an acceptable level, the exposure of the skin to a chemical hazard. Type and extent of chemical hazard, necessity for additional protections such as eye or respiratory protection, expected duration of exposure are some of the key aspects considered before selecting the protective clothing. Operations such as work with highly toxic chemicals, handling of hazardous chemicals, emergency operations, etc, may require full-body protective clothing. Based on these considerations, selection of garment, selection of material of construction and selection of design should be made.

There is no ISO standard on this subject. Assistance has been derived from BS 7184: 1989 'Recommendations for selection, use and maintenance of chemical protective clothing' in developing this standard.

The composition of the Committee responsible for the formulation of this standard is given in Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Indian Standard

CHEMICAL PROTECTIVE CLOTHING — SPECIFICATION

1 SCOPE

This standard provides requirements and methods of sampling and tests for chemical protective clothing. It also gives guidance for the selection of clothing intended to protect the skin against contact with chemicals and prescribes the basic requirements for the fabric.

2 REFERENCES

The Indian Standards given below contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1964 : 2001	Textiles—Methods for determination of mass per unit length and mass per unit area of fabrics (*second revision*)
1969 : 1985	Methods for determination of breaking load and elongation of woven textile fabric (*second revision*)
6359 : 1971	Method for conditioning of textiles

3 TERMINOLOGY

For the purpose of this standard the following definitions shall apply.

3.1 Air-Impermeable Materials

Materials through which permanent gases cannot pass except by undergoing a process of solution.

3.2 Air-Permeable Materials

Materials having pores or apertures that allow the transmission of air.

3.3 Breakthrough Time

The elapsed time between the initial application of a chemical to the appropriate surface of the material and its subsequent presence on the other side of the material.

3.4 Chemical Hazard

The potential of a chemical to cause harm to the human body by contact with the skin.

3.5 Chemical Protective Clothing

A garment which covers or replaces personal clothing, and which is designed to provide protection against one or more chemicals.

3.6 Chemical Resistance

Chemical protective clothing's ability to withstand specific chemicals under a wide range of environmental conditions.

3.7 Garment

An individual item of protective clothing, the wearing of which affords protection to the skin against exposure to or contact with chemicals.

NOTE — For the purpose of this standard, gloves and boots are treated as garments.

3.8 Gas-Tight Suit

A one-piece garment with hood, gloves and boots which, when worn with self-contained or compressed air-line breathing apparatus, affords the wearer a high degree of protection against harmful liquids, dusts and gaseous or vapour contaminants.

3.9 Hazard

Situation which can be the cause of harm or damage to the health of human body. There are different types of hazards, for example, mechanical hazards, chemical hazards, fire hazards, temperature hazards, radiation hazards, biological hazards, ergonomic stresses, etc.

3.10 Penetration

The passage of chemicals, in any physical form, from the outside of the clothing to the inside via essential openings, fastenings, seams, overlaps between items, pores and any imperfections in the materials of construction.

3.11 Permeation

A combined process of molecular diffusion of a chemical through a solid material forming the whole or part of clothing and its desorption into a specified medium. Permeation is determined in terms of Permeation Rate and Breakthrough Time.

3.12 Permeation Rate

The rate at which a chemical permeates through the protective material. It is expressed as $mg.cm^{-2}.min^{-1}$ or $\mu g.cm^{-2}.min^{-1}$.

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3.13 Total Protection Suit

Chemical protective suit combining eye/face protection, respiratory protection, hand protection, body protection, leg/feet protection into one full-body covering.

4 TYPES

The protective clothing shall be classified into the following four types based on the breakthrough time as indicated in Table 1 and when tested in accordance with Annex A.

Table 1 Classification Based on Breakthrough Time in Relation to Type of Application

Type	Breakthrough Time	Action if Contaminated	Application
(1)	(2)	(3)	(4)
1	Over 6 h	Wash off/clean at the end of work period	Long term continuous exposure
2	2 to 6 h	Wash off/clean at the end of work period	Routine tasks
3	12 min to 2 h	Wash off/clean immediately	Short term protection
4	Up to 12 min	Remove as soon as possible	Emergency use/disposable garments only

5 REQUIREMENT

5.1 Material

5.1.1 Chemical protective suits shall be made from a fabric (treated cotton or artificial fibre) coated with synthetic elastomers like neoprene, styrenes, butadiene rubber, etc. The coating shall be free from pinholes and there shall be no exposed textile on the surface that could provide a path for liquid penetration by wicking. Some of the primary construction materials of total protection suits are given in Table 2 for guidance.

Table 2 Primary Construction Materials of Total Protection Suits for Chemicals

Layer 1	Layer 2	Layer 3
(1)	(2)	(3)
Butyl	Nylon	Butyl
Butyl	Polyester	Chloroprene
Chloroprene	Nylon	—
PVC	Nylon	—
PVC	Polyester	—
PVC	Nylon	PVC

NOTES

1 The primary construction materials are described with the external surface first (layer 1) and surface facing the wearer last (layer 3).

2 Unsupported laminated PVC films are also used for making these suits, but as the possibility of accidentally puncturing or tearing such films is greater than for a textile based material, they are less suitable for high risk applications and total protection suits. Generally, such unsupported plastics film or rubber sheet is used to construct aprons or similar garments, especially clothing designated as disposable.

5.2 Fabric

5.2.1 The fabric used for the protection clothing shall be as given in Table 3.

Table 3 Specification for Chemical Protection Suit Fabric

Sl No.	Characteristic	Requirement	Test Method Ref to	
			IS	Annex
(1)	(2)	(3)	(4)	(5)
i)	Mass per area g/m², *Min*	300	1964	—
ii)	Breaking strength, kg/cm², *Min*		3322	—
	a) warp direction	12		
	b) weft direction	8		
iii)	Dimensional change, due to cleaning, in percent		—	Annex B
	a) lengthwise	± 3		
	b) breadthwise	± 3		

5.2.2 When observed with naked eye, the material shall not show any sign of cracking due to weathering effect or when exposed to corrosive chemicals.

5.2.3 Reliable chemical resistance test data shall be obtained from the manufacturer before selection of the fabric. A general chemical-resistance selection data shall provide information on permeation of the chemicals against which its use is recommended. Such permeation data shall contain breakthrough time (in hours) and permeation rate (in $\mu g.\ cm^{-2}.min^{-1}$).

NOTE — *Permeation by chemicals* — Even without any surface flaws or holes, coatings can absorb certain chemicals, which are thus able to diffuse by permeation through the material. This process proceeds broadly in three stages:

a) initial absorption of the chemical by the polymer film or coating;

b) solution of the chemical in the polymer film or coating;

c) desorption from the opposite surface of the material into the internal environment of the garment.

Annex A gives a method of test for the determination of breakthrough time and for the amounts of chemicals permeating thereafter. In selection of the protective garment material the results of such tests should be considered. Having got the permeation data the risk of chemicals coming into contact with the skin when air-impermeable protective clothing is worn may be minimized by following the actions indicated in Table 1. Typical permeation data for various glove materials are given in Tables 4 and 5.

6 PROTECTIVE CLOTHING

6.1 General

6.1.1 The materials and components of protective clothing shall not be known to adversely affect the wearer.

6.1.2 Parts of the protective clothing that can come into contact with the user shall be free of roughness, sharp edges and projections that could cause irritation or injuries.

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6.1.3 The threads shall be of same chemical resistant material or of equivalent material.

6.2 Size and Design

6.2.1 Adequate size range shall be provided so as to enable protective clothing to be adapted to the morphology of the user. The size and design of the clothing shall be as agreed between the purchaser and the supplier.

6.2.2 The control dimensions for protective clothing shall be height, chest or bust girth and waist girth.

6.2.3 The size designation of each garment shall comprise with at least two control dimensions in millimetres. These two control dimensions shall be either:

a) height and chest or bust girth, or
b) height and the waist girth.

NOTE — These control dimensions should be designated as ranges expressed in millimetres. A range interval of 60 mm for height and 40 mm for chest or bust girth and waist girth are recommended.

6.2.4 Where applicable, protective clothing design shall take into account other items of protective clothing or equipment which must be worn to form an overall protective ensemble. The same level of protection shall be provided at interface areas, such as sleeve to glove, trouser, cuff and hood.

6.3 Seam Strength

6.3.1 Seams shall be so constructed and sealed (by using a double overlap type of seam or other appropriate design) to prevent penetration of liquid through stitch holes or, by penetration or permeation, through other components of the seam. The performance of the seam in these respects shall not be inferior to that of the material from which it is made.

6.3.2 The seam strength of the garment shall not be less than 185 N (19 kgf) at the load bearing seams and shall not be less than 135 N (14 kgf) at other seams when tested in accordance with the procedure prescribed in Annex C.

6.4 Pockets

Pockets weaken the resistance of the base fabric at the seams, present the risks of snagging, and may collect spilt or splashed chemicals. Thus garments designed to protect against serious hazards shall not have any external pockets.

6.5 Fastenings

Since fastenings (zip fasteners, etc) are weak points, care shall be taken, particularly in high performance garments, in the design (placement of fastenings, covering flaps, overlaps) to ensure adequate sealing. All fasteners shall be able to withstand the cleaning operations used on the garment.

Table 4 Solvent Breakthrough Time (in Hours) for Various Glove Materials
(Clauses 5.2.3 and 6.7)

Solvent	Glove Material					
	Natural Rubber	Neoprene	Neoprene + Natural Rubber	Nitrile	PVC	PVA
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Carbon tetrachloride		0.03-0.5	0.08->1.0	0.07	1->8	0.01-0.66 >3
Chloroform	0.01-0.05	0.01-0.36	0.05-0.11	0.07-0.30	0.01	>6
Methylene chloride	0.01-0.10	0.01-0.22	0.03-0.07	0.03-0.15	0.01-0.20	0.28->8
Methyl iodide	0.03-0.05	0.01-0.28	0.03-0.09	0.01-0.13	0.02	>8
1,1,2,2-tetrachloro-ethane	0.03-0.35	0.09->1	0.15	0.22-1.2	0.01-0.10	>8
1,1,2-trichloroethane	0.02	0.12	—	0.03	0.03	0.25–>8
Perchloroethylene	<0.02–0.1	0.10–0.80	0.05-0.30	0.22-7.3	<0.01-0.75	0.35->16
Methanol	0.02-6	0.25->8	0.10-1.1	0.18-3.2	0.02-6	0.02-0.04
Ethanol	0.02->8	1-12.6	0.17->1	>1->8	0.03-0.33	1.67
2-propanol	0.02->8	>1->6	0.10-0.83	>6	0.5->3	—
N-butanol	0.02-1.2	4->8	0.25-1.2	>6	0.42-3	0.5->8
Benzene	0.01-0.18	0.02-3.1	0.05	0.07-1.0	<0.01-0.5	0.05->33
Toluene	0.01-0.68	0.02-0.52	0.07-0.20	0.13-1.2	<0.01-0.47	0.02->25
Aniline	0.25->8	0.25->8	0.09->6	0.30-5.4	0.05->16	>1->16
Phenol	0.27->8	0.35->8	>6	0.53->8	0.05-1.3	>6
Acetone	0.02->3	0.04->1	0.05-0.43	0.07-0.30	<0.02-0.30	0.07->4
Methyl ethyl ketone	0.02-0.17	0.04-2.8	0.08-0.10	0.06-0.33	0.02-0.27	0.10-7
Tetrahydrofuran	0.02-0.11	0.02-2.5	0.02-0.06	<0.01-0.28	0.01-0.10	4.7
Dimethyl sulfoxide	0.02->6	<0.01->8	0.7->6	<0.01->4	0.05-1.0	—
Dimethyl formamide	0.25-0.11	0.02->6	0.25-0.77	0.02->5	0.23-1.0	0.08-0.37
Pyridine	0.03-0.43	0.03-0.63	0.14-0.23	0.09-0.25	0.02	0.52
Dioxane	0.08-0.45	0.09-1.8	0.10-0.30	0.28-1.1	0.01-0.11	>16
N-hexane	0.08	0.06-3.3	>0.08	>1->8	0.20-0.42	>6
Water	—	—	—	—	0.25	—

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Table 5 Solvent Permeation Rates (in $\mu g.cm^{-2}.min^{-1}$) Through Glove Materials

(Clauses 5.2.3 and 6.8)

Solvent	Glove Material					
	Natural Rubber	Neoprene	Neoprene + Natural Rubber	Nitrile	PVC	PVA
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Carbon tetrachloride	2 664	1 036	3 858	22	967	3
Chloroform	7 856	3 227	5 711	6 079	12 606	—
Methylene chloride	4 529	2 360	1 348	4 269	8 312	1
Methyl iodide	10 794	4 896	8 917	7 976	—	—
1,1,2,2-tetrachloro-ethane	2 765	1 173	3 206	2 204	3 466	—
1,1,2-trichloroethane	—	—	—	—	1 236	—
Perchloroethylene	2 222	770	995	72	516	5
Methanol	32	15	11	77	30	545
Ethanol	12	3	4	5	24	30
2-propanol	4	5	4	5	24	30
N-butanol	15	5	1	—	18	49
Benzene	2 185	545	1 739	549	2 037	12
Toluene	1 579	1 439	1 803	478	2 030	85
Aniline	13	7	15	215	75	—
Phenol	17	25	—	283	104	—
Acetone	330	243	96	2 066	340	37
Methyl ethyl ketone	746	641	432	1 546	721	3
Tetrahydrofuran	11 202	6 456	16 699	2 650	—	3
Dimethyl sulfoxide	78	30	4	78	102	—
Dimethyl formamide	298	97	126	120	138	716
Pyridine	621	732	350	3 266	—	402
Dioxane	300	345	224	770	2 793	—
N-hexane	751	130	—	284	180	—
Water	—	1	—	—	—	—

6.6 Air-Tightness

The loss of pressure due to leaks shall not exceed 20 mm H_2O (1 mm H_2O = 10 N/m^2 or 10 Pa) in a period of 6 min, when the suit is tested in accordance with Annex D.

6.7 Breakthrouth Time

The chemical protective clothing of different types shall conform to the requirements given in Table 1. However, breakthrough time for different materials have also been given in Table 4 for guidance.

6.8 Liquid Permeation Rate

The liquid permeation rate for chemical protective clothing of different types shall conform to the requirements as agreed to between the purchaser and the supplier.The liquid permeation rate for different materials has also been given in Table 5 for guidance.

7 MARKING

7.1 Each piece of protective clothing shall be marked on the product itself or on label attached to the product so as to be visible, legible and durable to the appropriate number of cleaning process.

The protective clothing shall be marked with the following details:

a) Name;

b) Trade-mark or other means of identification of the manufacturer; and

c) A size tag specifying the chest or bust girth and height shall be positioned inside the garment sewn in the collar seam.

7.2 The marking shall also include the designation of the product or base material type and commercial name. Washing or cleaning instructions shall be given on the label.

7.3 The marking ink shall be non-irritating to skin and shall not impair the quality of the protective clothing.

7.4 BIS Certification Marking

The chemical protective clothing may also be marked with the Standard Mark.

7.4.1 The use of the standard mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

8 PACKING

The suits shall be dusted with talc and packed individually in PVC covers.

9 SELECTION

Selection of the chemical protective clothing shall be in accordance with Annex E.

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ANNEX A
(*Clauses* 4, 5.2.3, 6.7 *and* 6.8)

PROCEDURE TO DETERMINE BREAKTHROUGH TIME AND PERMEATION RATE

A-1 PRINCIPLE

The test specimen acts as a barrier between one compartment of the permeation test cell containing the test liquid and the other compartment through which a stream of carrier gas or liquid is passed for the collection of diffused molecules of the test liquid or its component chemicals for analysis.

The mass of the test liquid or its component chemicals in the collecting medium is determined as function of time after application to the test specimen. From the graph of mass of the test liquid *vs* time, the breakthrough time and the steady state permeation rate after the breakthrough time are determined.

A-2 REAGENTS

A-2.1 Gaseous Collecting Medium

Either dry air or a dry, non-flammable inert gas. This gas is used, under continuous flow conditions, for the collection of diffused molecules from the test liquid capable of vapourizing under the conditions of the test in sufficient quantities for analysis.

A-2.2 Liquid Collecting Medium

Either water or another liquid which does not influence the resistance of the test specimen to permeation. This liquid is used, under continuous flow conditions, for the collection of diffused molecules of low volatility that are soluble in the collecting medium under the conditions of the test in sufficient quantities for analysis.

A-3 APPARATUS

A-3.1 Permeation Cell

This comprises two flanged compartments that can be bolted together to form a cylinder. The dimensions are as shown in Fig. 1. The upper compartment for containment of the test liquid is fitted with a loose cover to avoid build-up of pressure and prevent excessive contamination of the immediate environment when volatile chemicals are under test.

The lower compartment or flow compartment is of similar overall dimensions but has pipe-work to allow gas or liquid to circulate freely at the designated rates without build-up of pressure. The internal dimensions of the flow-through compartment and its pipe-work (internal diameter 4.5 mm) are critical to the performance of the test.

The permeation cell and pipe-work shall be made of inert materials. Brass apparatus is generally suitable for permeation tests by the gas-flow technique and PTFE or glass by the liquid-flow technique.

A-3.2 Temperature Controlled Room or Waterbath

To maintain a constant temperature to a tolerance of $\pm 1^{\circ}C$ over the period of test.

A-3.3 Equipment for Supply of Gaseous Collection Medium

This comprises compressed gas supply (for example, dry air, helium or nitrogen) complete with regulator, flow meter and pipe-work for connection to the inlet of the flow compartment of the permeation cell. The rate of flow shall be 520 ± 52 ml/min in the direction indicated in Fig. 1 (This is equivalent to approximately 30 compartment volume changes per minute).

The gas shall not be recirculated through the cell.

The required rate of flow may be obtained either by suitable control of the gas pressure at the inlet to the permeation cell or by providing a pump at the outlet from the analyzer. These alternate configurations are shown in Fig. 2. The choice of configuration is generally determined by the method of collection and/or detection of the test liquid or its component chemicals.

A-3.4 Equipment for Supply of Liquid Collecting Medium

This comprises liquid flow pump complete with regulator, flow meter and pipe-work for connection to the inlet of the flow compartment of the permeation cell. The rate of flow shall be 206 ± 21 ml/min in the direction indicated in Fig. 1 (This is equivalent to approximately 12 compartment volume changes per minute).

The materials of construction of the equipment are such that no parts of the pump, associated pipe-work and flow meter shall contaminate the liquid to be passed through the flow compartment of the permeation cell.

The collecting liquid shall not be recirculated through the permeation cell.

A-3.5 Equipment for Measurement of Mass of Test Liquid or its Component Chemicals in Gas or Liquid Collecting Medium

This may include instruments responding directly to changes in concentration in the stream of gas or liquid, or may include absorbers and sampling equipment associated with specific analytical procedures.

The analytical system should, where possible, have a minimum sensitivity for the selected component

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chemicals of 1 μg/min/cm² of exposed specimen. The maximum response time should be 60 s. Whatever apparatus is coupled to the permeation cell to measure concentrations in the collecting medium, the pressure and flow of the collecting medium within the permeation cell should be maintained constant.

A-3.6 Stop Watch

This should be capable of measuring to the nearest second.

A-4 TEST SPECIMENS

A-4.1 Selection

From a flat sample of the material submitted for the test, cut from the same location a minimum of 3 test specimens of the same diameter as the flange of the permeation cell, avoiding as far as possible any obvious perforations, surface defects or pinholes.

The testing of 3 similar specimens is intended to establish the test method has been carried out correctly, as defined in **A-5**.

If permeation testing is to be used to establish the uniformity of quality in a larger area of test material, for example, a roll of sheet, then an appropriate statistical sampling technique should be used. In this case, 3 samples should be tested from each sampling site to demonstrate consistency of the permeation test.

When defects in the test specimens may be such as to allow gross quantity of the test liquid to pass into the flow compartment, due account should be taken of the potential consequences of overloading the analytical detection equipment.

A-4.2 Preparation of Test Specimens

Use a template to mark on the test specimen the positions of the bolts used to clamp the two halves of the cell together. Cut circular holes to allow the bolts to pass freely through the test specimens when placed between the two halves of the permeation cells.

A-5 PROCEDURE

A-5.1 Preparation of Apparatus

Mount the test specimen between the two halves of the permeation cell. Ensure that the surface of the test specimen corresponding to the outer surface when in use is uppermost in the cell, facing the compartment used to contain the test liquid. Check that the test specimen is not under tension when laid in position over the bolts. Tighten the bolts to obtain a leak tight assembly.

Where appropriate, take precautions to avoid transference of liquid from the top to the under surface of the test specimen. These precautions apply in particular if, for example, the top surface acts as a wick and the under surface is rough, when liquid may be drawn by capillary action across the top surface and reach the under surface via the bolt holes.

Place the assembled permeation cell, complete with leak tight pipe-work and connections to the appropriate equipment (*see* **A-3**), in the temperature controlled room or water bath at the required temperature.

The test should be conducted at the temperature most relevant to the use of the material or, in the absence of other preference, at 20°C.

Connect the appropriate gaseous or liquid collecting medium and adjust the flow through the permeation cell to the required rate and allow the system to stabilize. Connect the system to suitable analytical equipment and recheck the flow characteristics.

A-5.2 Assessment of Breakthrough Time and Subsequent Mass of Permeating Liquid

Bring the test liquid to the required test temperature and maintain this temperature within ±1°C for the duration of the test.

Discharge 10 ml of the test liquid rapidly into the upper compartment of the permeation cell and start the clock. Ensure that the appropriate surface of the test specimen is completely covered with the test liquid throughout the period of the test.

If the density of the liquid is high, and the strength of the sample under test is low, for example, thin latex films, the weight of liquid may distort the test sample, leading to an increase in sample area. In this case, the liquid volume may be reduced but care should be taken to ensure that the test sample is completely covered with the test liquid throughout the period of the test.

Analyze, either continuously or at appropriate intervals of time according to the equipment used, the collecting medium that forms the effluent stream from the lower compartment of the permeation cell.

Using appropriate calibration factors, calculate from each analysis the cumulative mass of test liquid or its component chemical (s) that has been desorbed from the test specimen into the collecting medium at measured times after the initial discharge of the test liquid.

Record the results and plot a graph showing the cumulative mass as a function of time, as illustrated in Fig. 3. When the slope of the curve becomes constant, continue the test for a further 60 min. Repeat the test with the other two test specimens.

A-5.3 Assessment of Physical Condition of Test Specimen

Remove the test specimen from the permeation cell. Inspect each test specimen in a well-lit area by the

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naked eye (use spectacles if necessary to ensure normal vision) and observe whether or not the test specimen has been changed in any way by its contact with the test liquid. If any change is observed, note whether the test specimen has become flaked, swollen, disintegrated and/or embrittled. Note the nature of any other changes.

A-5.4 Expression of Results

For each of the test specimens, make a linear extrapolation of the slope in the graph, which corresponds to the approximate steady state permeation rate, until the line cuts the X-axis. The breakthrough time is represented by the intercept with the X-axis and is expressed in minutes. Record the individual values of the breakthrough times and calculate the mean.

Record the mass of the test liquid or its component chemicals permeating in the 30 min and 60 min periods following the breakthrough time by reading the corresponding values directly from the cumulative graph.

Record whether the test specimens have been changed in any way and, if so, whether they have become flaked, swollen, disintegrated, or embrittled. Record the nature of any other change that has been observed.

A-5.5 Calibration

Calibrate the response of the analytical system to the test liquid or its component chemicals and, where appropriate, ensure that concentrations up to saturation of the collecting medium may be determined.

A-6 REPEAT TESTS

A-6.1 Assess whether the results obtained from any one test specimen accord with a requirement that they should lie within 20 percent of the corresponding mean of the results taken over the set of test specimens.

Experience in the development of this method indicates that this requirement is generally met with, provided that the test specimens have been drawn from a material that is physically homogeneous and is not subject to distortion or decomposition when in contact with the test liquid.

A-6.2 If the results accord with the requirement given above, prepare the test report as described in **A-7**.

A-6.3 If the results do not accord with the requirement, prepare a second set of test specimens and repeat the tests.

A-6.4 If the results thus obtained from the second set of test specimens accord with the requirement given in **A-6.1**, include only these results in the test report.

If the results obtained from the second set of test specimens do not accord with the requirements given in **A-6.1**, combine the results of both sets of test specimens in the preparation of the test report.

In this case further appropriate checks should be made to discriminate between those variations that arise from real differences between test specimens and those variations arising from an undue degree of experimental error in the procedure described in **A-5.1** to **A-5.5**.

A-7 TEST REPORT

Begin the test report with the following statement:

'The greater the degree of distortion of the specimen through absorption of the test liquid, the greater is likely to be the variation between the results from repeat tests.'

The test report shall include the following information:

a) that the test was carried out in accordance with this Indian Standard;
b) the manufacturer's reference for the material submitted for test;
c) the identity of the test liquid(s) used and, as appropriate, of any component chemical(s) to which the analytical procedures described in **A-5** have been applied;
d) the temperature, in degree Celcius, used in the test;
e) the mean and individual values of the breakthrough times, in minutes;
f) the mean and individual values of the mass of test liquid or its component chemical(s) permeating 1 cm^2 of the test specimens in 30 min and 60 min after breakthrough;
g) a copy of the graph(s) used in the calculation of the data;
h) a description of the analytical technique including a statement of its sensitivity and precision;
j) the identity of the collecting medium;
k) where appropriate, the particular part of a garment from which the material submitted for test was taken;
m) if appropriate, a description of those obvious perforations, surface defects or pinholes that have affected the selection of test specimens;
n) a statement of whether or not the test specimen(s), during its contact with the test liquid, has changed in any way, as has been noted by subsequent visual inspection and/or shown signs of flaking, swelling, disintegration, embrittlement or other physical changes; and
p) any comments considered appropriate by the person carrying out the tests.

Such comments might include a statement of the steady state permeation rate expressed as $\mu g.cm^{-2}.min^{-1}$.

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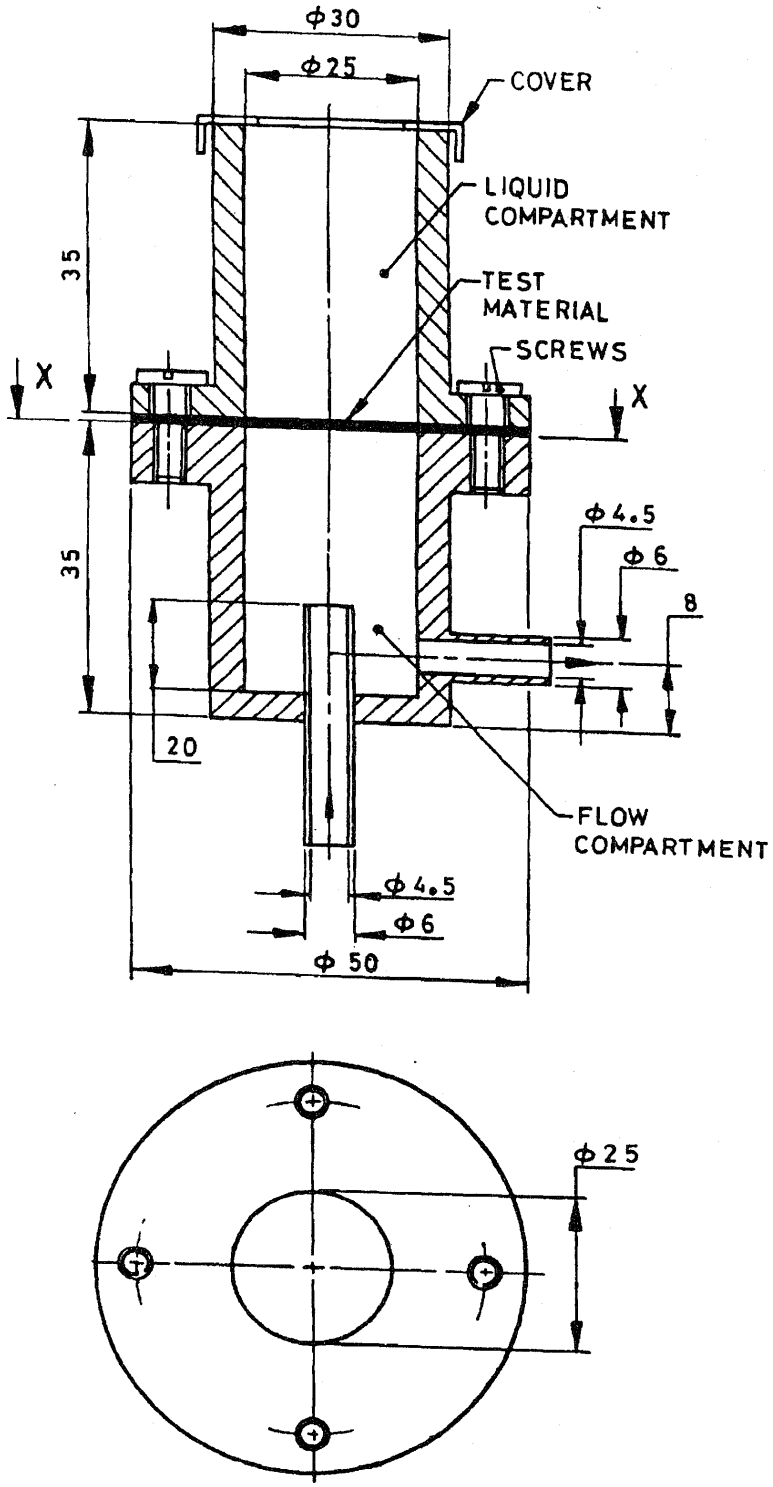

(NOTE — Exposed area of test materials : 4.91 cm²; and volume of flow compartment : 17.2 cm²)

All dimensions in millimetres.

FIG. 1 PERMEATION CELL

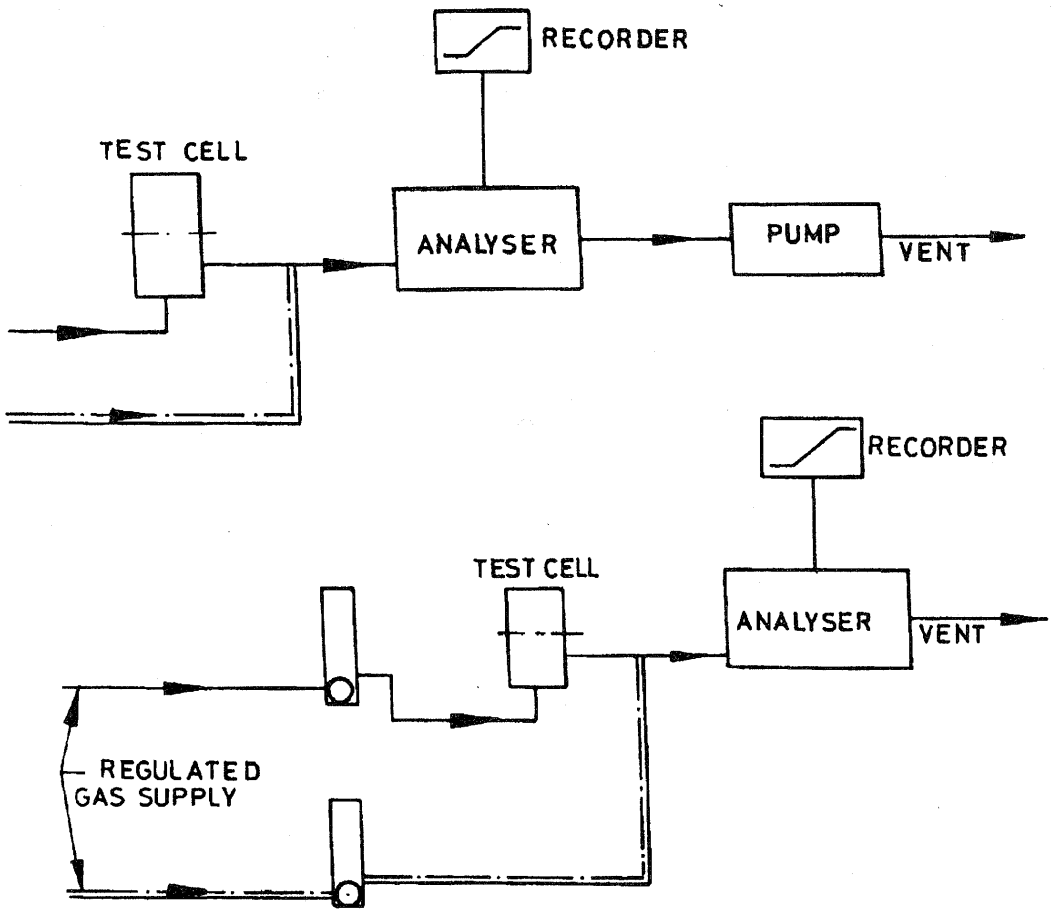

FIG.2 SCHEMATIC OF ALTERNATIVE ARRANGEMENTS OF EQUIPMENT

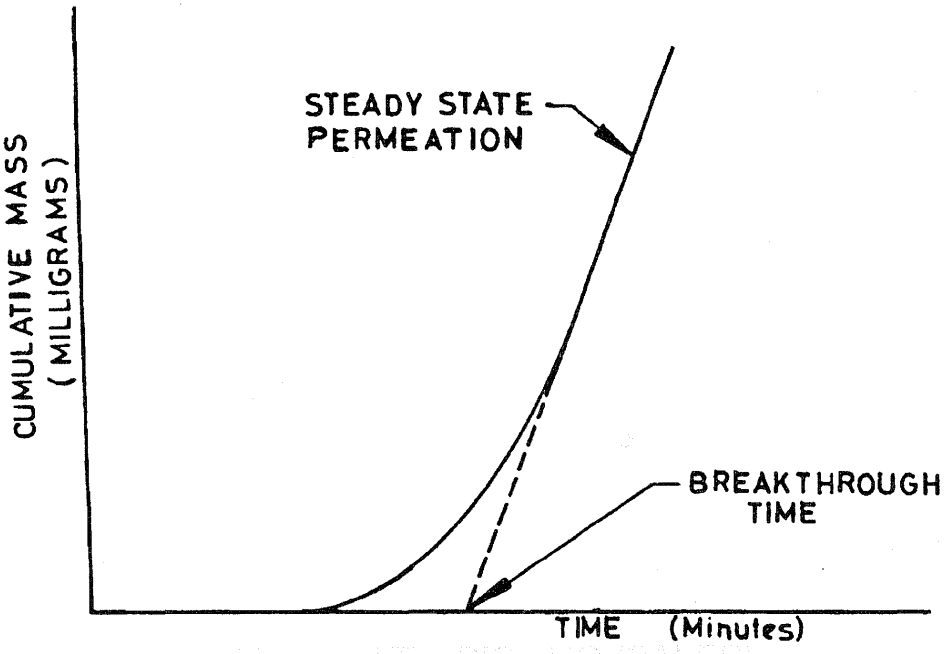

FIG. 3 BREAKTHROUGH TIME AND STEADY STATE PERMEATION RATE

ANNEX B

[*Table* 3, *Sl No.* (iii)]

METHOD OF TEST FOR DIMENSIONAL CHANGE

B-1 GENERAL

Follow the washing or dry cleaning instructions of the manufacturer, if a detailed cleaning procedure is provided by the manufacturer. In case of lack of such guidelines from the manufacturer, the following general procedure shall be followed.

B-2 WASHING TREATMENT

Prepare a wash liquor of neutral detergent solution of concentration 2 g/l using soft water. Adjust the washing machine to a temperature of 40°C. Place the fabric specimen and the wash liquor in the wash tub up to the full level of the washer. Start the washing at the set temperature and continue for a period of 12 min to complete one cycle. Subject the fabric for 5 such washing cycles. Remove the fabric, rinse with same quality water, dry and condition and check the change in dimension both in length and in width.

B-3 DRY-CLEANING

If dry-cleaning is recommended, the fabric is placed in a container with a dry-cleaning solvent to get a material to liquor ratio of 1 : 5. Seal the jars, clamp in launderometer and run it at room temperature for 10 min and drain. Repeat the above process 2 times to complete one cycle. The fabric shall be subjected to 5 such cycles. Remove the specimen, blot thoroughly, air dry and condition. Check for change in dimension.

ANNEX C

(*Clause* 6.3.2)

METHOD OF TEST FOR SEAM STRENGTH OF GARMENT

C-1 APPARATUS

A constant rate of extension textile testing machine as described in IS 1969 shall be required.

C-2 PREPARATION OF TEST SPECIMEN

Cut specimen from a double thickness of fabric that includes a seam such that the seam lies midway between the ends and perpendicular to the major axis of the specimen, when prepared and opened out as shown in Fig. 4.

The specimen shall be 50 mm wide and 100 mm long. Cut one specimen from each main load bearing seam of the garment ensuring that the following seams are included:

a) an armhole seam; and
b) the seat seam.

Specimen from each non-load bearing seam of the garment shall also be cut for the test.

C-3 Condition the test specimen from dry side in the standard atmospheric condition of 65 ± 5 percent relative humidity and 27 ± 2 °C for 24 h, as specified in IS 6359, before carrying out the test.

The test shall be carried out in the standard atmospheric condition.

C-4 Carry out the test in accordance with IS 1969. Ensure that the seam lies midway between the jaws of the testing machine and perpendicular to the direction of pull as shown in Fig. 4.

C-5 Record the seam strength of each of the load bearing seam specimen in Newtons and find out the mean value. Also establish the seam strength of non-load bearing seam specimens.

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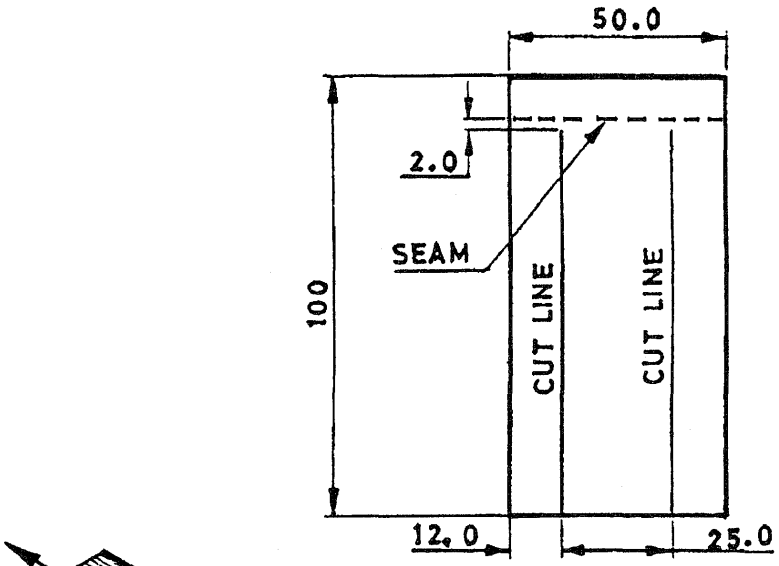
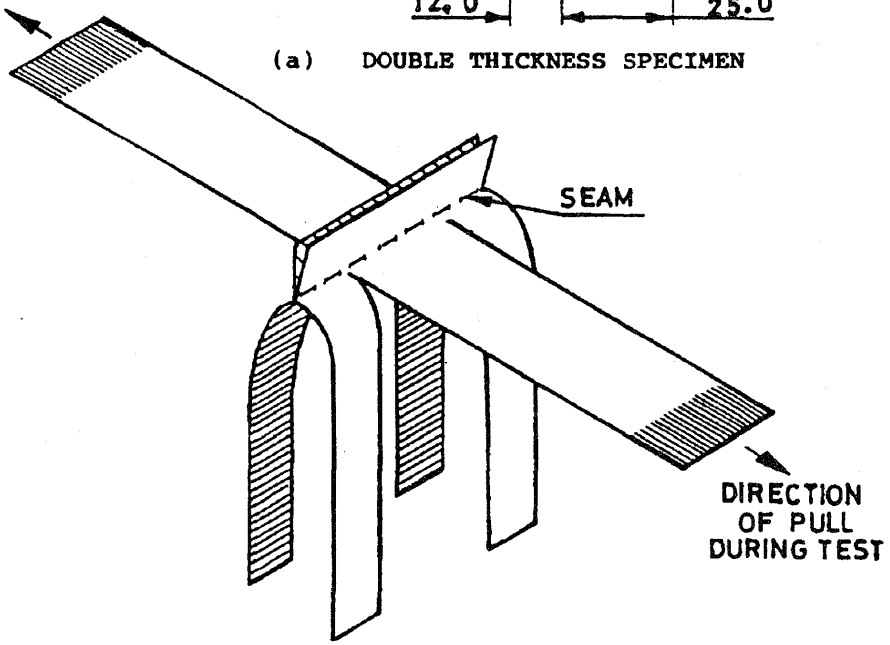


(a) DOUBLE THICKNESS SPECIMEN



(b) OPENED OUT SPECIMEN

All dimensions in millimetres.

FIG. 4 SPECIMEN FOR SEAM STRENGTH

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ANNEX D
(*Clause* 6.6)

LEAK TEST FOR GAS-TIGHT SUITS

D-1 PRINCIPLE

The suit is inflated and the loss of pressure over a defined period is noted.

D-2 PROCEDURE

D-2.1 Lay out the suit including gloves and boots, and facemask, if appropriate, on a suitable flat and clean surface away from any source of heat and/or draught.

D-2.2 Remove any creases or folds in the suit as far as practicable. Make an inflation connection and carefully blank off the valves, etc, with appropriate components as recommended by the manufacturer.

D-2.3 Inflate the suit carefully to a maximum pressure of 180 mm H_2O, and then allow it to settle for a period of at least 10 min to allow any creased areas to unfold, the suit to stretch, the temperature to stabilize and the pressure throughout the suit to reach equilibrium.

D-2.4 Adjust the pressure in the suit to 170 mm H_2O.

D-2.5 Allow a further period of 6 min to elapse and note any loss of pressure.

NOTE — Pay careful attention to the cleanliness and the refitting of valves which have been obstructed or removed in order to carry out the test, to ensure that they function satisfactorily after the test.

ANNEX E
(*Clause* 9)

SELECTION OF PROTECTIVE CLOTHING

E-1 SELECTION OF GARMENT AND MATERIAL OF CONSTRUCTION

The following points shall be taken into account in selecting the garment and material of construction of the protective clothing:

a) seriousness of the chemical hazard,
b) need for eye and/or respiratory protection,
c) need for coveralls,
d) need for special boots,
e) need for air-impermeable garment(s),
f) chemical resistance required of the garment,
g) duration of such a requirement, and
h) durability of the garment or protective clothing.

Discussions with safety experts, chemical manufacturers, occupational experts, and garment manufacturers are necessary for correct selection of garment and material of construction.

E-2 SELECTION OF DESIGN

Compatibility with other protective equipment, ergonomic considerations, maintainability, etc, are some of the main design aspects considered for the protective clothing. Figures 5 and 6 schematically depict such a selection procedure.

E-3 TOTAL PROTECTION SUIT

This type of suit offers full body protection from exposure to the chemical against which it is recommended. The components of such a total protection suit that prevent chemical exposure are:

Hoods
Coverall/ clothing
Gloves
Boots
Visors
Air connections

Complete cover garments and gas-tight suits are examples of such total protection suits.

E-4 COMPLETE COVER GARMENTS

Complete cover garments (*see* Fig. 7) can be worn with some form of visor and respirator or breathing apparatus to protect eyes and face and to guard against inhaling chemicals.

Where the danger to the skin is small, air-permeable garments together with specially approved respiratory protection may be acceptable when dealing with chemicals in powder form.

Otherwise an air-impermeable assembly should be adopted comprising one-or-two piece plastics or elastomer coated coverall, gloves, boots and complete head protection. Hoods should be sufficiently large to accommodate goggles, etc, comfortably, and (if attached to a coat-like garment) to allow the weight of the garment to be taken by the wearer's shoulders, rather than by the head.

For protection where particularly hazardous chemicals are not involved, and respiratory protection is thus not indicated, air-permeable coveralls worn with gloves, goggles and boots are often adequate.

E-5 GAS-TIGHT SUITS

Total protection suit used to protect against gases and vapours that are skin-absorbed (for example, HCN) shall

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provide a gas-tight environment. Relevant literature (for example, the current Threshold Limit Values Booklet by the American Conference of Governmental Industrial Hygienists) should be referred to identify skin-absorbed substances.

To isolate wearer completely from environment (for example, from a toxic gas) an all-enveloping garment shall have no pinholes and be proof against passage of the gas by dissolution in the membrane (*see* Fig. 7).

If the breathing apparatus is isolated from the interior of the suit, the latter is effectively a sealed container. Any chemicals entering by permeation cannot be swept away and a greater concentration of contaminant will build up than in the case of air-fed suit. Breathing apparatus (which may be either inside or outside the suit) is obviously necessary. Reinforcement of the part of the suit in contact with the apparatus may be desirable to give added support and to reduce the risk of abrasion to the suit.

A gas-tight, air-supplied suit, in which the interior of the suit is purged and conditioned by an external air supply while breathing air is fed from separate air line or self-contained breathing apparatus, provides maximum protection for both skin and lungs.

The arrangement for use of the breathing apparatus shall be of one of the following forms:

a) where the breathing apparatus is to be worn over the suit, the breathing apparatus face mask shall be bonded or otherwise attached in a leak-tight manner as an integral part of the suit and arranged so as to permit the face mask to seal on the wearer's face by means of the normal seal and head harness of the mask concerned. Access to the face mask seal and head harness shall not be affected in any way.

b) where breathing apparatus is to be worn inside the suit, the suit shall have a transparent face piece and be of sufficient size to accommodate the self-contained breathing apparatus worn wholly within the suit. The suit shall be designed so as to permit the wearer to manipulate the controls and adjust the head harness of the breathing apparatus, including the supplementary air supply.

E-6 COMBINATIONS OF EQUIPMENT

When protective clothing is worn together with other forms of personal protective equipment, such as respiratory protective equipment, eye protection, protective helmets and/or hearing protection devices, whose primary function is other than protection of the skin as such, the following recommendations apply:

a) Care should be taken that no new or additional hazard is introduced;

b) Whatever the primary function of each individual garment or item of personal protective equipment, the personal protective equipment as a whole should afford due protection to the skin; and

c) As far as practicable, the personal protective equipment as a whole should fit the wearer and be comfortable in use.

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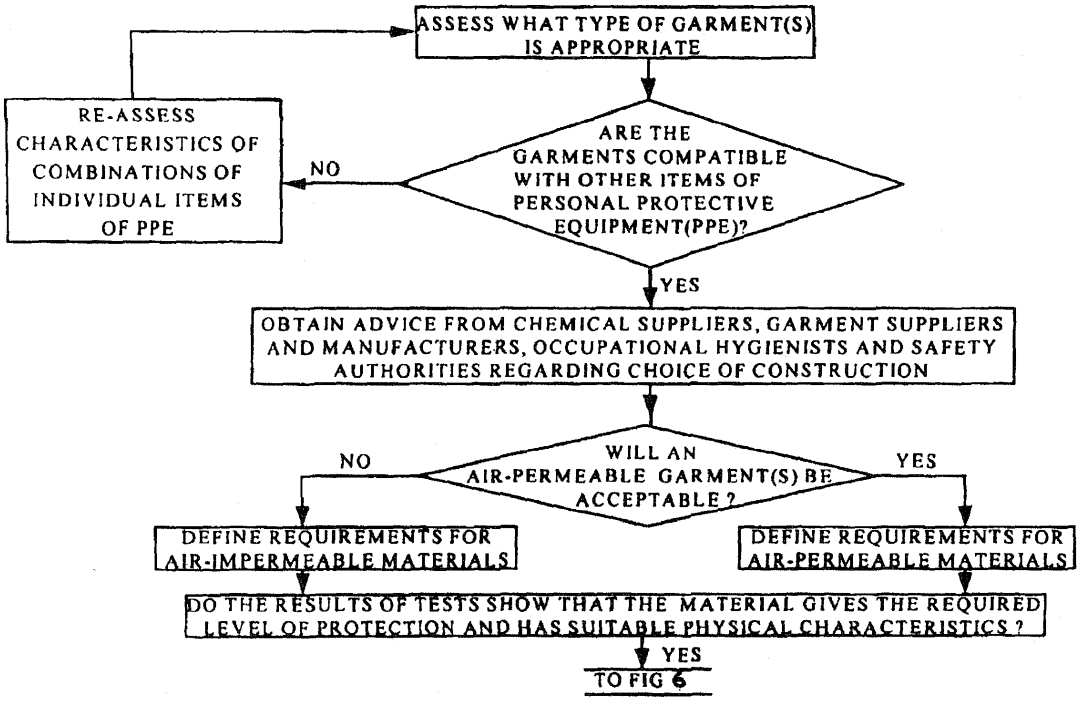

FIG. 5 SCHEMATIC DIAGRAM FOR SELECTION OF TYPE OF GARMENT AND MATERIAL OF CONSTRUCTION

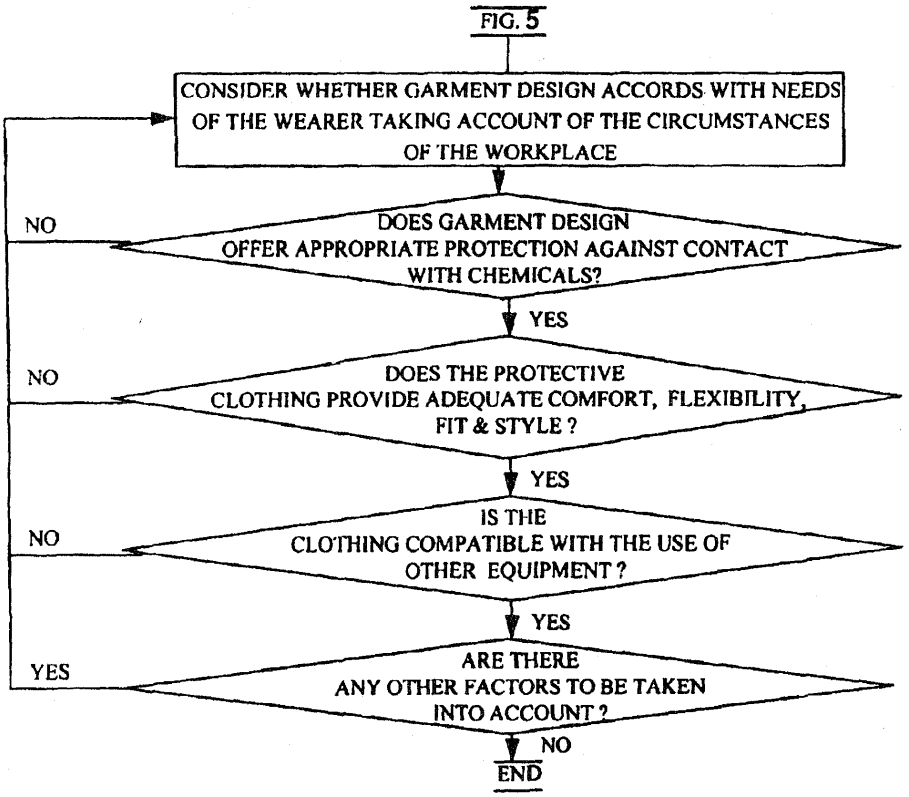

FIG. 6 SCHEMATIC DIAGRAM FOR CONSIDERATION OF PROTECTIVE CLOTHING DESIGN

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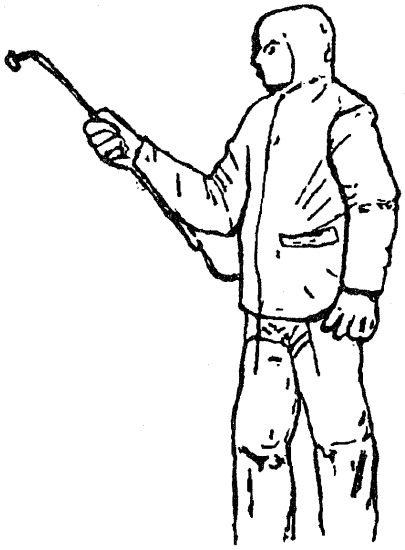
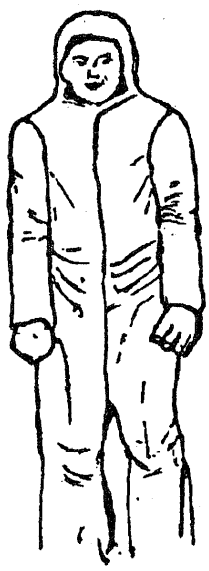
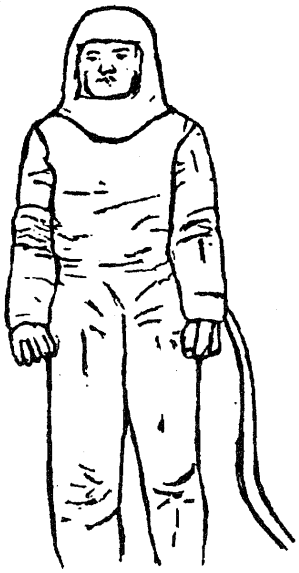


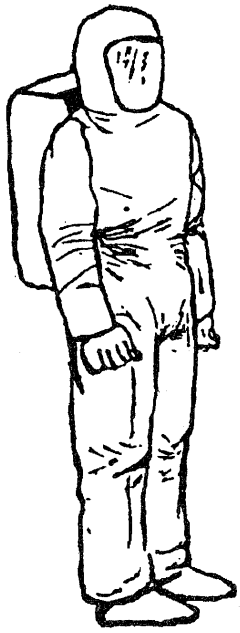
(a) TWO-PIECE SPRAY SUIT



(b) ONE-PIECE COVERALL WITH HOOD



(c) AIR-SUPPLIED CLOTHING



(d) GAS-TIGHT COVERALL WITH SELF-CONTAINED BREATHING APPARATUS

FIG. 7 TYPES OF COMPLETE COVER GARMENTS

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ANNEX F
(*Foreword*)

COMMITTEE COMPOSITION

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(*Continued on page* 17)

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(*Continued from page* 16)

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Amendments Issued Since Publication

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